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Control of Potato Diseases in Oregon

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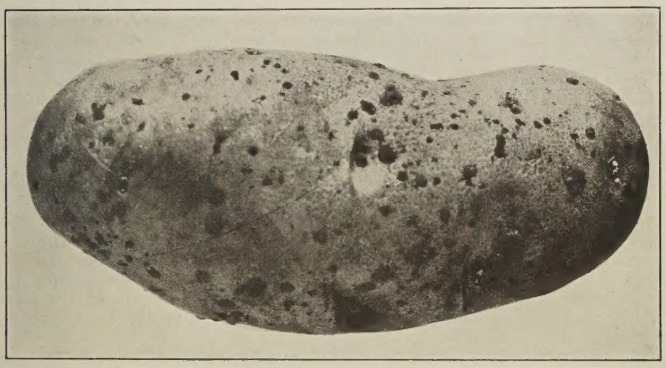

Rhizoctonia or Black Scurf, Oregon's most destructive potato disease.

CORVALLIS, OREGON

Oregon State Agricultural College and
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CONTROL OF POTATO DISEASES IN OREGON

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INTRODUCTION

Potato growing is an important industry of Oregon and is generally a profitable one. The acreage in potatoes, however, and the average yield per acre have been decreasing during recent years, particularly in certain sections of the State where the soil diseases have been especially prevalent, for this decrease in the production of potatoes has been very largely due to disease. A comparatively few years ago only three potato diseases were considered serious in the United States. Now there are recognized a half dozen generally serious diseases and a score of less important ones of very common occurrence, which occasionally, however,

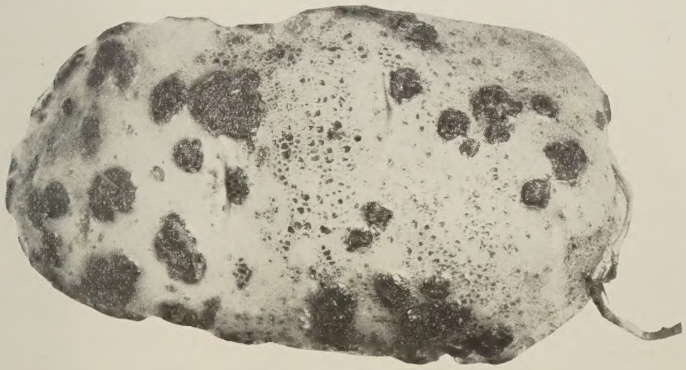

Fig. 1. Common Scab (After F. D. Bailey).

are themselves quite serious. This comparatively rapid increase in the number of diseases affecting potatoes, is due in part to the continuous culture of potatoes on the same land for a period of several years. This unfortunate practice furnishes excellent conditions for the propagation of the common diseases and for the origination of new ones.

A careful potato-disease survey made by the Experiment Station during the past summer in a number of representative fields in several sections of the State, showed that a surprising number of serious diseases was present in varying amounts and attacking from a few to 85 percent of the plants in different fields. As a result, of course, the yields were greatly reduced as compared to what they should be when intelligent care is exercised in the prevention of these diseases.

It is hoped that the information contained in this bulletin will satisfactorily meet the requests which are being made by a large number of interested potato growers for information on the identification and control of the commoner potato diseases of Oregon. It is anticipated that the demand for such information will increase as a result of the movement toward official certification of potatoes which has been undertaken this year for the first time in this State and which has already been successfully maintained in a number of other states.

GENERAL CONTROL MEASURES

It is fortunate that practically all of the diseases attacking the potato can be successfully controlled by comparatively simple and inexpensive measures. It should be borne in mind that the control of these diseases **depends entirely on prevention and not on cure.** If, for instance, a potato leaf is infected with late blight, it can not be cured

Fig. 2. Powdery Scab (After Bailey).

of the disease, although the spread of this disease to other leaves or other plants can be prevented by spraying properly.

There are five important factors to be considered in the prevention and control of potato diseases; namely, rotation, seed selection, seed disinfection, spraying, and improvment of storage conditions. All of these factors must be carefully considered if the grower is aiming at the production of potatoes high in yield and practically free from disease.

Rotation. Inasmuch as a number of the organisms which cause diseases of the potato live for part of the time in the old tops and other refuse left in the soil after harvest, the practice of rotation is imperative where these diseases are present and a disease-free product is desired. Not all fields grown continuously in potatoes for several years develop disease to a serious extent, because the seed used may have been free from disease, but such cases are very rare. In every section

of the United States and of the world, in fact, where potatoes have been grown continuously or very frequently on the same pieces of ground over a considerable area for several years, the result has always been the same; namely, that the diseases became so severe that profitable yields could no longer be secured and large acreages had to be abandoned for potato culture. As concrete examples of this we may mention the San Joaquin Valley of California and the Greeley district of Colorado.

Fig 3. Blackleg. Plant showing the black rot progressing up from the lower end of the stem. (After Bailey).

It is known that some of the organisms producing disease in potatoes remain alive in the soil for at least three years, even though no potatoes are grown on the land during that time. Consequently it becomes necessary to practice longer rotations than this in order that the organisms may die out of the soil before potatoes are again planted on such land. It is therefore best that potatoes be not grown on the same land oftener than once every four or five years, the ground in the meantime being planted to other crops not affected by the potato parasites.

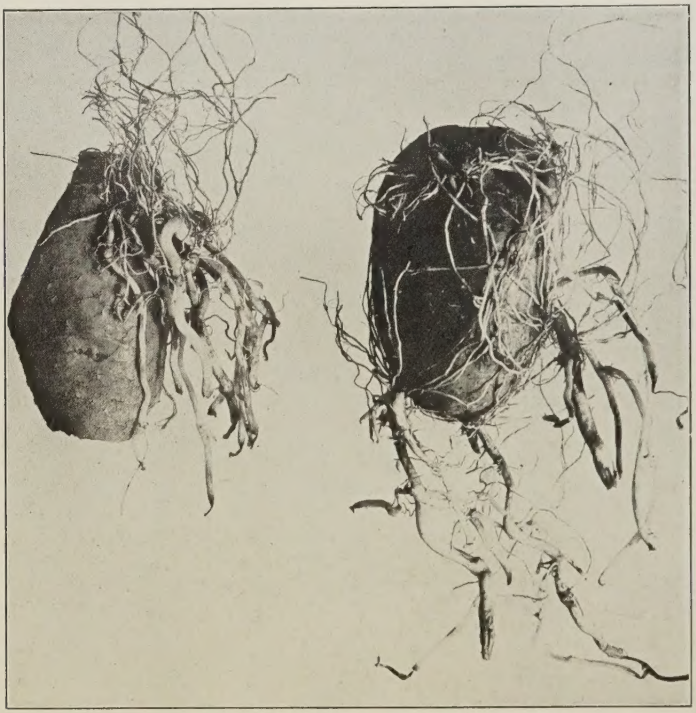

Fig. 4. Burning off of young sprouts due to Rhizoctonia. This is often a cause of poor stands. (Original).

Seed Selection.* Seed selection should be practiced for three purposes; namely, increase in yield, greater uniformity in size and shape of tubers, and greater freedom from disease. The methods in each case are essentially the same, that is, the selection, either during the growing season or before general harvesting time, of hills which are free from disease, high in yield, and which possess the desirable qualities of the variety under selection. By choosing such potatoes for seed the

*For a more complete discussion of this subject than is given here consult Oregon Agricultural College Extension Bulletin No. 185, February, 1917.

yield and vigor of the crop can be improved in quantity and quality so that these advantages very much more than offset any added expense for labor involved in the selection process.

If selection has not been made in the field before harvest, it is good practice to start the improvement of the potato crop by selecting from the bin for planting the following season tubers which are smooth, uniform, free from blemishes and disease, and which weigh between 2 and 8 ounces.

In Minnesota, for instance, where selection and disinfection of the potato tubers before planting were combined in some experiments the following results were secured:

Results (1) of Selection and Disinfection on Ten Farms in Minnesota, 1915.

Kind of seed used.	Percent stand	Percent of plants diseased at flowering-time and later	Yield in bushels per acre	Percent of culls in harvested product	Increased yield in bushels per acre as a result of seed selection and disinfection
Selected and treated ..	100	0.9	130.6	2.8	44.4
Unselected and untreated	91.6	3.6	86.2	8.6	

(1) Adapted from Minnesota Agricultural Experiment Station, Bulletin No. 158, February, 1916.

In addition to the increase in yield of 44.4 bushels per acre the quality of the potatoes grown in the selected and treated plots was much better than that of those grown in the check plots due to the reduced amount of skin diseases on the former. Also the reduction in stand in the plots planted with unselected and untreated seed was largely due to the killing of very young plants by blackleg and Rhizoctonia.

In Wisconsin in 1915 the certified potatoes grown from selected potatoes sold on the average for 50c a bushel more than ordinary potatoes on the farm at the same time. In California in 1915 there was a corresponding difference of 25c in the average selling price of the two classes of potatoes.

These instances show something of the value to be gained by practicing care with the potato seed planted.

Seed Disinfection. Due to the fact that a number of skin diseases, such as scab, Rhizoctonia or black scurf, etc., are so often present on the potatoes in this State, it is desirable that all potatoes, whether they show evidences of disease or not, be treated by a disinfecting solution before they are planted. Provided of course that the potatoes are not planted in soil already infected with disease-producing organisms, seed treatment will not only control these diseases mentioned, but it will also aid in controlling others, such as wilt, blackleg, dry rot, etc. This is effected by killing the spores that may be on the surface of the potatoes, and that, if not killed, might produce disease later on. Before treating any potatoes, however, it is always best to run them over a slat-work sorting table or rack and discard all tubers which are bruised, cracked, or show evidence of decay. This will also remove much of the dirt, which interferes with the disinfecting solutions.

There are two materials in general use for disinfecting potatoes; namely, formaldehyde and mercuric chloride prepared and used as follows:

Formaldehyde (40% commercial solution) .....1 pint
Water .....30 gallons
Soak the potatoes in this solution for two hours and spread out to dry.

Or

Mercuric chloride (Corrosive sublimate) .....4 ounces
Water .....30 gallons
Soak the potatoes in this solution from one and one-half to two hours and dry before planting.

Fig. 5. Brown dead areas (x) on stalks due to Rhizoctonia. The stalks are occasionally completely girdled. (Photo by J. H. Corsaut).

In making this latter solution up for use the proper amount should be carefully weighed out and may be dissolved in a small quantity of hot water in a clean wooden or porcelain container, but never in a metal container, as the solution corrodes metal and rapidly loses strength. The solution may then be diluted to the desired amount in similar containers, when it is ready for use. A convenient way to make up this solution is to have the dealer from whom the mercuric chloride is purchased weigh it out in small amounts to be dissolved in a given

quantity of water for the required dilution, which is at the rate of one part of mercuric chloride to one thousand parts of water by weight. In using this mercuric chloride solution it should be borne in mind that this material is very poisonous, and if potatoes are once treated with it they should never be used for human consumption or for feeding to animals.

The mercuric chloride solution is the one that should be used in this State in preference to the formaldehyde, for it controls other troubles as well as the formaldehyde does and in addition the Rhizoctonia or black scurf disease. This will be discussed later on.

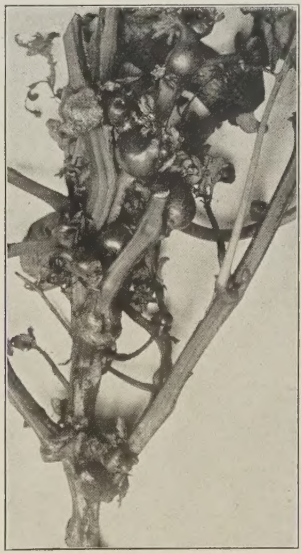

Fig. 6. Small potato-like growths (aerial potatoes) in top of plant due to severe attacks by Rhizoctonia on the underground portions of stalks. (After Bailey).

These solutions lose their strength through use, or on standing, so for best results they should not be used more than four times, after which a new solution should be made up to treat other potatoes. The potatoes may be soaked in these solutions in sacks or crates and after disinfection should be dried thoroughly before being planted or before being placed in storage again if the planting is not to be done immediately. Care should be taken not to reinfect the potatoes by placing them back in the same bags or storage places unless they too are disinfected. (For disinfection of storage bin see under "Storage Conditions").

Until there is more experimental evidence at hand to prove otherwise, it seems to be the safer and better practice always to treat the potatoes before cutting, and not after they are cut, as occasionally

the seed pieces are apparently considerably injured by the solution if they are treated after being cut. In cutting potatoes, it is advisable to have for each cutter two or three knives, which, when not in use, are to be kept with their blades immersed in a strong solution of formaldehyde. When cutting, reject every tuber which shows any signs of disease or discoloration of the interior, especially near the stem end.

Fig. 7. Rhizoctonia. White moldy growth, the fruiting stage of the fungus, on a stalk above the ground surface. (Photo by Corsaut).

Drop the knife used in cutting the discolored tuber into the formaldehyde at once to prevent infecting other seed with it and take out one of the other knives to use until another suspicious potato is cut.

Spraying. In order to control certain of the leaf diseases such as late blight or early blight, spraying of the potato plants must frequently be resorted to. For this purpose Bordeaux mixture has proved to be

the most efficient spray mixture used, of which the following formula is most frequently employed and is apparently best for potatoes:

Copper sulfate (Bluestone)	5 pounds
Lump lime	5 pounds
Water	50 gallons

This is briefly and commonly expressed as 5-5-50 Bordeaux. A weaker solution such as 3-4-50, may often be used with good results if it is thoroughly applied.

A convenient and satisfactory method of making up this spray mixture is to dissolve the 5 pounds of copper sulfate in 25 gallons of water by suspending it in a sack near the top of the water over night, as it dissolves slowly; slake the lime gradually in a small amount of water and dilute the milk of lime to 25 gallons, then pour the two solutions together into a third barrel or through a strainer directly into the spray tank and stir vigorously. The resulting mixture is Bordeaux and is of a milky blue color. The spray mixture should be strained as it

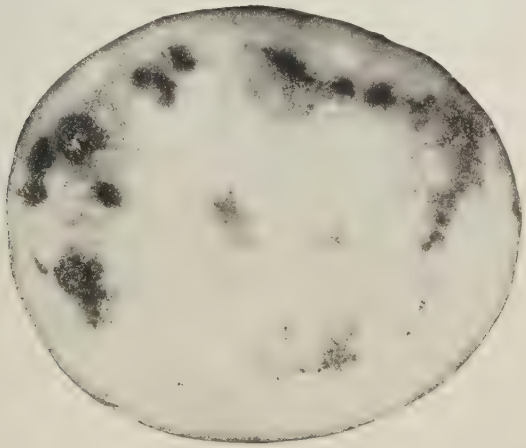

Fig. 8. Wilt. Extreme discoloration of potato tuber extending in from the stem end due to an attack by wilt. Usually the discoloration does not extend farther than one-half inch into the potato from the stem end. (After Bailey).

is put into the spray tank, since otherwise the small particles held in suspension are very apt to clog the spray nozzles and cause considerable trouble. The spray mixture is then ready for use and should be applied at once. If it is impossible to spray at once due to bad weather or other unfavorable conditions, half a pound of sugar dissolved in a small amount of water should be added to each barrel of 50 gallons of spray mixture. This will keep the spray mixture in good condition for a long time, even two or three months, though without the sugar added the mixture would have lost most of its value and been practically worthless in even one day's time.

In case large quantities of Bordeaux mixture are to be used, it will be found convenient to make up stock solutions of the copper sulfate

and lime at the rate of one pound to one gallon. These stock solutions should be kept well covered when not in use to prevent undue evaporation and should always be well stirred up before any is removed for making Bordeaux mixture. Then when 5-5-50 Bordeaux is desired, 5 gallons of the copper sulfate stock solution and 5 gallons of the milk of lime stock solution may be diluted and mixed with 40 gallons of water for the desired spray mixture. These solutions should be mixed for the Bordeaux, however, only when it is to be used immediately as it loses value if it stands for more than a few hours, unless the sugar is added as mentioned above.

The largest increases in yields as the result of spraying have been secured when the spraying was begun while the plants were from six to eight inches in height and continued at intervals of about every

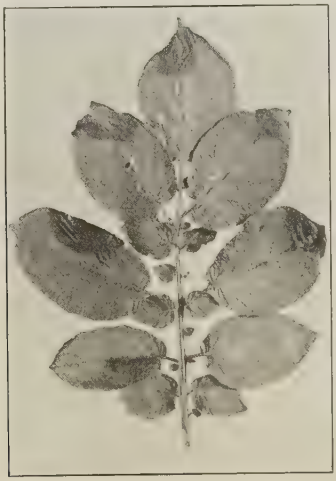

Fig. 9. Late blight. Dead areas on leaves, showing the usual appearance of the leaves when the disease first attacks them. (Original).

two weeks. Much benefit has been derived, however, by commencing later in the season and spraying only three times. In Oregon probably the only disease which should be sprayed against regularly is late blight. The first application of spray should be made at least by the time the disease first appears.

A convenient and satisfactory spray machine is one that will maintain at least 100 pounds of pressure, that will spray thoroughly four rows of potatoes at a time, and that is geared to the truck. The spraying should be thoroughly done, using preferably three nozzles to each row, as the plants must be covered with the fine mist in order to be effectively protected.

Storage Conditions. A considerable part of the loss of potatoes due to disease is brought about by various tuber rots in storage. There are a number of distinct rots of potato tubers caused by different organisms and without exception they are most severe when the stor-

age temperatures are high and when the air becomes heavily laden with moisture due to lack of proper ventilation. For instance, neither the powdery dry rot which is so prevalent and serious in the eastern part of the State, nor the dry rot which is apparently widely distributed all over the State will develop seriously in storage if the temperature is kept at from 35° to 40° F., and if the storage place is kept well ventilated. It is also well known that the shrinkage in weight of potatoes in storage is much greater when the temperatures are allowed to remain high than when they are kept down to from 35° to 40° F. These facts show the necessity of surrounding the stored potatoes with the proper storage conditions, in order that the serious losses from storage rots and from shrinkage in weight may be avoided.

Fig. 10. Entire potato plants in the field killed by late blight. (After Bailey).

Potatoes in large quantities should never be placed directly in storage if they have become heated by high day temperatures. They should first be thoroughly cooled to prevent as far as possible the natural heating which takes place and to start the storage period under as favorable conditions as possible. This cooling may often be done with convenience and economy by leaving the potatoes outside the storage place until well cooled by night temperatures and then moving them into storage either late at night or early in the morning before they have had an opportunity to become heated again by external conditions.

A good storage place embodies the following requirements: ease and thoroughness of ventilation, ability to prevent rapid changes in temperature inside in response to rapid changes in the temperature of the atmosphere outside, convenience in cleaning, conveniently arranged

for use, ample in size, and durable. In many sections of the United States where potatoes are an important cash crop these essentials are most efficiently secured in the cellars constructed half underground and half above, with three or more ample-sized ventilators in the top, and with large doors and a driveway in at one end large enough to accommodate a wagon for convenience in loading or unloading the potatoes.

Another type of storage place used with much satisfaction in this State is the double-walled, sawdust-lined bin with the walls about six inches thick and with ventilators on the side, which, when the days are warm, may be left open at night and kept closed in the daytime, with the result that the whole bin is kept reasonably cool all the time. All storage places should be provided with a thermometer, so that the temperatures may be regulated intelligently. Injury is produced when the temperatures are too low as well as when they are too high. With the dry rot it appears that the critical time, the time when much of the loss from this disease results, is during the first two months after digging, when the temperatures are apt to be higher than during any

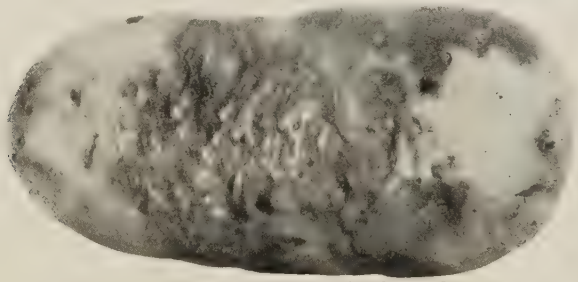

Fig. 11. Tuber showing slightly sunken dark-colored rotted areas due to the late-blight fungus. (After Bailey).

other part of the storage period. It is at this time that our potatoes need especially to be surrounded by the favorable storage conditions that are best secured only in a good storage place.

All storage places and particularly those in which rotting of the potatoes was bad the previous year should be thoroughly cleaned and disinfected before potatoes are again placed in storage in order to kill all the potato rot-producing organisms already present. To accomplish this, the storage places may be swabbed or sprayed with either of the following solutions:

Copper sulfate (Bluestone) . 1 pound Water . . . . . 10 gallons	Or	Formaldehyde . . . . . 1 pint Water . . . . . 10 gallons

After being disinfected the storage place should be well aired and dried out before potatoes are again placed in it.

POTATO DISEASES

The first step in the successful control of any disease is the accurate recognition of the symptoms or appearances of the particular disease under consideration; it is for this reason that the following brief but

specific descriptions of the diseases are given, together with definite measures recommended for their control.

PARASITIC DISEASES

Under parasitic diseases are listed the diseases of the potato known to be due to living organisms on or within the tissues of the potato.

Common Scab, *Actinomyces chromogenus* Gasp., is confined in its attack on the potato entirely to the tubers. At first the spots are usually small and brownish but later enlarge into rough corky brownish

Fig. 12. Section of potato showing late blight rot as it usually appears at harvest time. (After Bailey).

patches (Fig. 1). A single scab spot is usually less than three-fourths of an inch in diameter, although a whole potato may occasionally be covered with scab due to the abundance of individual spots. The organism may also affect other host plants such as turnips, garden beets, sugar beets, etc.

The disease thrives best on alkaline soils and consequently lime, ashes, and fresh manure tend to increase scab when they are placed on land just before potatoes are planted. These materials, therefore, should be avoided at that time but may often be used with profit with other crops following potatoes. Poorly drained or wet soils also favor the development of scab so an excess of moisture is to be avoided on potato land. To prevent the introduction of scab on seed potatoes, treat them with either formaldehyde or mercuric chloride, and then plant on land which has not grown potatoes for at least four or five years.

Powdery Scab. *Spongospora subterranea* (Wallr.) Johns. This disease is quite different in nature from common scab but resembles it in appearance. On potato tubers in typical cases the spots are at first covered and blister-like, later they break open, forming roundish raised pustules surrounded by the torn skin of the potato (Fig. 2) and exposing a brownish powdery mass of spores. The spots when mature are generally less than a quarter of an inch in diameter.

This disease is quite serious in Europe and Canada. It has recently been found in this country in a number of states from Maine to Minnesota and also in Oregon in Tillamook and Clatsop counties. So far it has not proved so serious in the United States as was at first feared. It may never become serious here, but precautions should be used to prevent its spread by not planting infected potatoes. It is not satisfactorily controlled by seed treatment.

Blackleg, *Bacillus phytophthorus* Appel, et al. The common name of this disease is taken from the appearance of attacked plants. In typical cases the diseased plants die in the early part of the season due to a black relatively dry decay of the main stalk progressing up from the point where it is attached to the parent tuber (Fig. 3). Plants less severely attacked or not affected till later in the season produce potatoes which if harvested and planted are very apt to carry the disease over to the next season. It is not known whether or not the disease

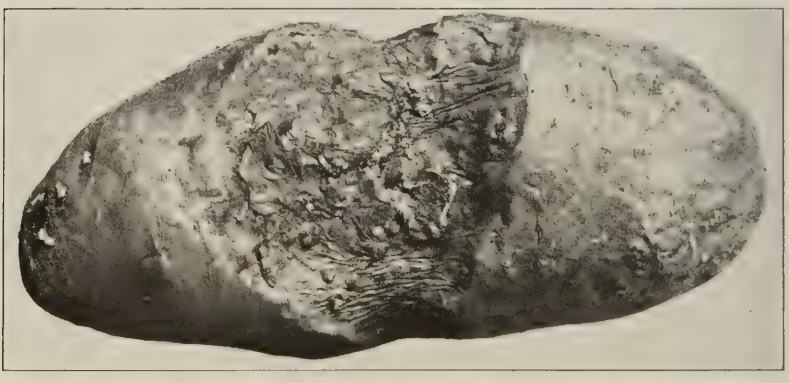

Fig. 13. Dry Rot. Probably the commonest and most serious storage rot in Oregon. (After Bailey).

lives from one year to another in the soil. The disease can be very effectively prevented by planting only treated seed from healthy hills. If selection of healthy hills for seed has not been practiced during the past season, then one should sort out and discard all partly rotted potatoes in the bin and treat the remainder according to the suggestions given under "Seed disinfection."

Rhizoctonia or Black Scurf, *Corticium vagum* B. & C. This disease, which commonly goes by the name of black scurf due to the presence of black sclerotia or resting bodies of the fungus on the potato tubers at harvest time (coverpage), is apparently the commonest and most serious potato disease in the State. The disease manifests itself in a variety of ways, the most important of which are the following:

Often the young sprouts are attacked and are "burnt off" by the fungus even before they reach the surface of the ground. This may lead to the production of other new sprouts which in turn are also burnt off with the result that a rosette or cluster of sprouts are formed with

their tips killed, none of which reach the surface of the ground and are able to produce plants (Fig. 4). This is often the cause of the poor stands secured.

Plants attacked less severely or later in the season may develop lesions or dead areas on the underground stems (Fig. 5) and upon the stolons, which so interfere with the normal growth of the plant that the leaves may roll up considerably, small potatoes may form in the axils of the leaves or other convenient places in the top of the plant (Fig. 6) and a large number of small potatoes and a few large knotty ones may be developed underground. This result often gives rise to

Fig. 14. Powdery Dry Rot. Prevalent in Eastern Oregon. (After Bailey).

the term "little potato" disease. The yields in such badly attacked hills are practically worthless for seed as well as for commerce.

Near the base of attacked plants and extending up varying distances from the ground surface, a gray or white mold-like growth on the surface of the stalks (Fig. 7), may frequently be found from late June to the last of August. This is the fruiting stage of the fungus in which numerous spores are produced. It often has the appearance of being salts collected on the stalks from the soil, although the tops of such plants generally distinctly show evidences of abnormalities due to the attacks of the fungus.

The fungus often attacks other plants than the potato, though generally much less severely, therefore long rotations are essential to hold the disease in check when it is once well established in the soil. Seed disinfection with mercuric chloride is effective in killing the fungus present on the potatoes and should always be used. Formaldehyde will not control this disease.

Wilt, *Fusarium oxysporum* Schlecht, and *Verticillium alboatrum* Reinke and Bert. There are two serious wilt diseases in the State caused by distinct organisms, but the two diseases are so similar in appearance and effect that they may both be treated together. Attacked plants may wilt and die comparatively suddenly or they may succumb very gradually, finally dying only a week or two in advance of the unattacked plants in the same field. If the stalk of a wilted plant is cut across near the lower end, the interior will be found in most cases

Fig. 15. Armillaria rot, characterized by black thread-like strands clinging to the surface of the tubers. (After Bailey).

extensively browned, whereas in unattacked plants the tissue is normally white. If a thin slice is cut across the stem end of potatoes produced in a wilted hill a distinct brown or black discolored ring will generally be found present and extending into the tuber for varying distances depending on the severity of the disease (Fig. 8). Such discolored tissues indicate the presence of the organism that caused the wilting, in the interior of the potato, and such tubers, if used for seed, are very apt to give rise to the same disease the following year. Seed treatment is not effective in killing the fungus in the interior of the tubers. The organisms remain alive in the soil for some time, consequently long rotations are necessary. Plant only healthy potatoes from normal hills.

Late Blight and Rot, *Phytophthora infestans* (Mont.) de Bary. This disease is known as late blight, because in most sections of the country it attacks the plants most severely comparatively late in the season. In some places, however, and this is true of the Coast Region of Oregon,

the disease may appear early in the season, killing the young plants as early as July. The disease has been found a number of times along the Coast as early as June. The fungus invades the leaves, producing large dark brown to black dead areas (Fig. 9), and spreads rapidly through the leaf tissues without forming any distinct rings such as are produced in some leaf diseases. When the disease is severe, even the leaf stalks and tender tissues of the stems are invaded and killed. Under favorable warm and moist weather conditions the disease spreads rapidly both in the attacked leaves and onto other leaves not previously attacked, with the result that all the plants in an entire field may be killed in a very few days (Fig. 10). The diseased and decaying tissues give off a very noticeable odor, which becomes quite pronounced in fields heavily attacked. The organism also readily attacks the tubers, producing on them slightly sunken dark-colored rotted areas of irregular size varying from very small spots to areas involving the whole surface of the potato (Fig. 11). Generally at harvest time the rot does not extend very far into the potato tissues, usually not deeper than half an inch (Fig. 12). In storage, however, it may, and frequently

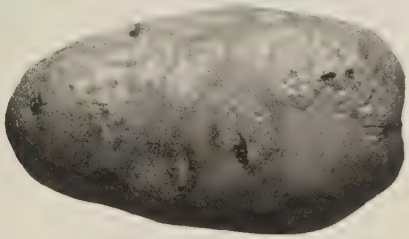

Fig. 16. Silver Scurf. Discolored areas on skin covered with fine black points. (After Bailey).

does, finally involve the whole potato with disastrous results, particularly if the temperature is allowed to remain high and the ventilation is poor.

If late blight has been particularly prevalent in the field late in the season and has entirely killed many or most of the potato plants, it is much better to delay digging the potatoes till two weeks after the potato vines have all died. This delay is necessary in order that the numberless spores of the fungus present on and about the old dead plants and on the surface of the soil may die before the potatoes are dug. If the potatoes are dug without this two weeks' delay, a large number of them will almost surely become infected by the live spores with which they come in contact during the digging process. In addition to delaying digging for two weeks after the plants are dead it may occasionally be advisable also to spray the old vines and the entire soil surface soon after the heavy attack with a solution of copper sulfate (bluestone) at the rate of 5 pounds in 50 gallons of water in order to kill as many as possible of the spores. In case this is done, thorough spraying of the soil surface is necessary because the spores falling from the plant become very abundantly distributed over the entire soil surface. Whether the spraying of the dead plants and the soil surface before digging is profitable or not will depend mainly on

conditions such as the value of the potatoes, the price of copper sulfate, labor, etc. Whether the soil is sprayed or not, however, the delay of two weeks before starting digging is always advisable under the conditions mentioned.

The disease is not serious in all sections of the State, being most serious near the Coast, occasionally destructive in the Willamette Valley and other points west of the Cascades, and rarely, if ever, present to any serious extent east of the Cascades.

Diseased potatoes should not be used for seed, as even a small rotting area not over a quarter of an inch in diameter may carry the disease to the young plant from which it can readily spread to the surrounding healthy plants. If the disease does begin to develop in a field, however, it can be successfully controlled if detected soon enough by thorough spraying with Bordeaux mixture. Where the disease is generally serious every year, one should commence spraying before the disease ordinarily appears, and continue at intervals of about two weeks during the rest of the season. Where the disease is not generally serious every year the first application of spray might be delayed until the first traces of the disease appear, and the later sprayings may be continued, if moist weather conditions prevail or the disease takes a new start.

Early Blight, *Alternaria solani* (E. & M.) J. & G. Early blight attacks only the potato leaves, causing brown spots thereon, which as they enlarge develop concentric rings or markings, producing a "target" effect. When the spots are numerous, they kill the leaves with a consequent reduction in the yield of the potatoes. In contrast to late blight this disease develops best in warm dry weather. It is not serious in this State but where present can be successfuly prevented by thorough and timely sprayings with Bordeaux mixture.

Dry Rot, *Fusarium coeruleum* (Lib.) Sacc. This is apparently the commonest, the most widely distributed, and the most destructive potato tuber rot in Oregon. It enters the potato generally through wounds and produces large sunken pockets, if only one side of the potato is attacked (Fig. 13); or a wrinkled decay, if a large part of the tuber is affected. Numerous bluish or white points or protuberances are formed on the surface of the decayed parts. This decay often develops extensively during the first month or two after harvest when the temperatures are high. It is not so serious in storage when the storage temperatures are kept low and the ventilation is good. Bruising of the potatoes at harvest time or during subsequent handling should be carefully guarded against. The disinfection of all storage places before storing in the fall is to be especially recommended.

Powdery Dry Rot, *Fusarium trichothecioides* Wollenw. This rot of potato tubers is serious in Oregon mainly only east of the Cascades. It appears to be limited mainly to warm dry climates. Affected tubers shrink considerably and often develop in the interior large hollow pockets partly filled with a pink powdery mass of fungous growth (Fig. 14). In storage the rot develops at a somewhat lower temperature than do many of the other common rots, though it is not serious if the temperature is kept at from 34° to 40° F. Avoid bruising the potatoes during digging and do not allow them to remain exposed on the ground very long after they are dug. When dry they should be

picked up at once and, as soon as they have cooled, placed, preferably at night or very early in the morning, in cool storage with good ventilation.

Armillaria Rot, *Armillaria mellea* Vahl. When potatoes are planted on newly cleared land containing much rotting wood or in prune or other orchards where Armillaria root rot is common, a number of the potato tubers are often attacked by the Armillaria rot. The rotting areas are light brownish, slightly sunken and generally have attached to them a few long black strands which are the rhizomorphs or root-like run-

Fig. 17. Spindle Sprout. None of the spindly stalks developed are able to produce a strong plant. (Photo by Bailey).

ners of the fungus (Fig. 15). The interior rotted portion of the attacked potato tuber is composed of alternating layers or flakes of yellowish and white tissue. This rot apparently does not continue to develop in storage, although other fungi commonly gain entrance and complete the destruction of the partly rotted tubers. While the rot is often encountered in the western part of the State the losses are not large. The largest individual loss that has come to our attention was three percent of the tubers grown in an old prune orchard. Avoid planting potatoes on newly cleared land the first year that it is in cultivation.

Silver Scurf, *Spondylocladium atrovirens* Harz. This disease is distinguished by the occurrence of irregular brownish areas on the skin of the tubers, which turn silvery and show many fine black points when moistened (Fig. 16). It causes some loss to potatoes in storage by injuring the skin, which permits considerable loss of water and consequent shriveling. It has been encountered in a number of places in the State only during recent years and it is not controlled by seed treatment. Avoid diseased seed and practice long rotation.

Fig. 18. Internal Brown Spot. Irregular brown spots or groups of cells which may occur at any place within the tuber. (Original).

NON-PARASITIC DISEASES

During recent years a number of diseases of potatoes apparently not due to the presence of any parasitic organisms have been receiving increasing attention by growers and investigators alike. These are all classed as non-parasitic diseases of which there are apparently two groups; namely, those of which the cause is not known and which are seemingly not due to climatic conditions, and those which are due to climatic or environmental conditions.

Diseases Due to Unknown Causes

In this group come mosaic, curly dwarf, leaf roll, and perhaps spindle sprout. Some of these diseases are widely distributed and are

causing great reduction in yields. A number of them are present to a serious extent in this State. They are transmitted from year to year in the tubers, though their presence can be determined only by an examination of the growing plants in the field, as there are no indications of the diseases in the tubers. Diseased potatoes appear to run out entirely and after a few years fail to produce any yield. Only healthy potatoes from normal hills should be kept for seed. If a field shows a large number of plants affected by these diseases, however, no potatoes should be used from it for planting the next year, but the seed should be secured from fields free of these inherited weaknesses.

Mosaic. This disease is characterized by a mottling in the green of the leaf, in which yellowish or light-colored areas alternate with the normal green of the leaf, and is accompanied generally by a crinkling but not a rolling of the foliage. Figures available show that the yield in badly affected hills is reduced approximately one-half as compared to normal hills.

Curly Dwarf. The stems, branches, and leaf veins of plants affected with curly dwarf are shorter than normal, giving the plants a dwarfed, bushy and crinkled appearance, accompanied at times by a pronounced curling and wrinkling of the foliage. The yields from such hills are very small.

Leaf Roll. The occurrence or establishment of this disease in Oregon is still somewhat in doubt, although it is said to be important in other states. Diseased plants are described as having an upward rolling of the leaves on the midrib, giving the leaves a tubular form and the plant a stiff erect appearance.

Spindle Sprout. In this disease numerous slender spindly sprouts are produced by the affected tuber when planted (Fig. 17), none of which succeed in producing a large plant or any appreciable yield.

Diseases Due to Climatic or Environmental Conditions

This group includes tip burn, internal brown spot, and net necrosis. These diseases are not inherited but depend on unfavorable conditions for their development.

Tip Burn. Tip burn is a drying and dying of the leaves, beginning at the tips and margins and working inward. The leaves often roll and becoming brown, present a scorched appearance. This trouble is usually most pronounced on light soils and during hot dry periods. If possible, maintain an adequate soil-moisture supply by irrigation or careful cultivation. This disease can be largely prevented by timely spraying with Bordeaux mixture due probably to the shading effect which this spray has on the foliage of the potato plant.

Internal Brown Spot. The development of irregular brown spots in scattered and irregular places in the interior of potato tubers (Fig. 18) is known as internal brown spot. These brown spots are free from bacteria or fungi and represent merely groups of cells which have died from some cause or other. The disease is generally believed to be due to lack of water at some period during the growth of the plants, perhaps as the result of poor soil or merely insufficient soil moisture. The trouble is not transmissible in the tubers. Affected potatoes, however,

are generally avoided for seed on account of the chance for predisposition of the affected potatoes to this disease.

Net Necrosis. This disease is characterized by the production of an extensive network of small brown strands of discolored tissue extending throughout the interior of the potato tuber tissue though occurring more abundantly in the tissues near the surface of the tubers. In some cases this condition is evidently brought about by chilling or frosting, but it is possible that other conditions may produce it also. The disease is not inherited, though affected tubers should be avoided as seed, due to the chance of confusing them with potatoes affected with wilt, which they slightly resemble.